

5.0

**SITE CHARACTERIZATION AND OTHER DATA
REQUIREMENTS FOR MRBCA PROCESS**

5.1 INTRODUCTION

This section presents:

- An explanation of the data necessary to implement the MRBCA process for petroleum underground and above ground storage tank (UST/AST) sites,
- A brief discussion of the techniques used to collect the data, and
- A description of the manner in which the data should be documented and reported to MDNR.

The data discussed herein will typically be collected subsequent to the confirmation of a release as part of the initial and comprehensive site characterization efforts. The objective of the data collection effort is to ensure that data of sufficient quality and quantity are available to:

- Develop a site conceptual model,
- Compare maximum site concentrations with the default target levels (DTLs, see Table 3-1),
- Compare representative concentrations or, for surficial soil under residential use, maximum concentrations, with Tier 1 risk-based target levels (RBTLs, see Tables 7-1(a) through (f)),
- Develop Tier 2 and Tier 3 site-specific target levels (SSTLs), if necessary,
- Compare the SSTLs with representative (or maximum, as discussed above) chemical of concern (COC) concentrations, and
- Develop a risk management plan (RMP), if necessary.

The risk assessment should be completed only after all relevant data has been collected and a site conceptual model has been developed.

To accomplish the above objectives, the following information is required:

- Chronology of site events,
- Nature, magnitude, and location of spill or release (including identification of COCs),
- Site information (e.g., physical features, land use, etc.),
- Adjacent land use and receptor information,
- Vadose zone soil characteristics,
- Saturated zone and groundwater characteristics,
- Characteristics of nearby surface water bodies,
- Distribution of the COCs in soil,
- Distribution of the COCs in groundwater, and

- Information about corrective action measures or risk management activities that have been conducted and are planned.

Note: Additional data beyond that discussed herein might be required to develop a RMP or to complete a Tier 3 risk assessment. For instance, the collection of natural attenuation parameters or data from vapor extraction or pump and treat pilot tests might be required to design an active remediation system. Due to the variability in the type of data that might be needed, the collection of this type of data is not discussed here. Rather, requirements for and collection of such data will be determined on a site-specific basis.

5.2 CHRONOLOGY OF SITE EVENTS

At some UST/AST sites, numerous site investigations, monitoring events, system removal activities, and remediation activities might have been conducted. These activities would typically have occurred over an extended period of time, perhaps several years. As part of the MRBCA evaluation, the person undertaking the evaluation must carefully review all existing data and identify any data gaps. As appropriate, a work-plan to fill-in the data gaps shall be prepared and submitted to MDNR for approval prior to implementation. Only after all the necessary data have been collected and full site characterization is complete should the person undertaking the evaluation proceed with the development of target levels.

The first step in the MRBCA evaluation is to develop a comprehensive chronology of events related to the aforementioned activities. A chronology of events will help create a comprehensive picture of the activities conducted at the site and identify gaps in those activities. The chronology shall include information regarding events such as:

- The date tanks were installed, removed and/or upgraded,
- Whether any contaminated soil was excavated and disposed of off-site,
- Date(s) when monitoring wells were drilled, sampled and gauged,
- Date(s) when soil samples were collected, and
- Dates when remedial activities were conducted.

Note that the intent of this exercise is to develop a clear understanding of historic site activities as they may impact current and potential future risk. Development of the chronology is not the “end in itself,” but rather a means to understand site conditions.

5.3 NATURE, MAGNITUDE, AND LOCATION OF RELEASE

Knowledge about the nature, location, and magnitude of a release(s) is necessary to (i) identify the soil and/or the groundwater source(s) at the site, and (ii) identify the COCs. The person performing the work shall collect as much of the following information as is available for each release that has occurred at the site:

- Location and date of the release,
- Quantity of the release,

- Type of product released, and
- Any interim corrective action measures already performed with respect to each release.

Release-related information can be obtained by a variety of means, including (i) reviewing inventory records, (ii) interviewing past and current on-site employees, and (iii) reviewing historic spill incident reports filed with MDNR.

5.3.1 Location and Date of Release

Identifying the location of a release helps define the soil and groundwater source area(s). Likely release locations at petroleum UST sites include (i) corroded or damaged tanks, (ii) piping, especially at pipe bends and joints, (iii) dispenser islands, and (iv) accidental releases while filling the USTs/ASTs. A release may occur within the surficial soil (0-3 feet below the ground surface (bgs)), subsurface soil (from 3 feet bgs to the water table), or, if the groundwater is shallow (less than about 15 feet bgs), below the water table.

Identifying the date of a release is necessary to identify the COCs, as discussed in Section 5.3.3 (the COCs are listed in Table 5-1). Based on the chronology, the entity performing the work shall review the operational history of the site to determine the location and date of the release(s). Often the exact location and date of the release will not be known. In such cases, soil and groundwater sampling (including field screening using a photoionization detector (PID) and visual observations) shall be used to identify the likely location and extent (vertical and horizontal) of the soil and groundwater sources. The exact number and location of samples to be collected will be determined on a case-by-case basis using professional judgement. Sampling plans must be approved by MDNR prior to implementation.

The location of soil and ground water sources shall be marked on a site map and included as an attachment to Form No. Tier 1-2.

5.3.2 Quantity of Release

The MRBCA process does not necessarily require knowledge of the exact quantity of the released petroleum. Often this information is not known. However, having a general idea of the amount released can assist in evaluating the severity of soil and groundwater contamination and the extent of the residual source. Information regarding the amount released is typically based on inventory records.

Information about the magnitude of the spill shall be reported on MRBCA Report Form No. Tier 1-3.

5.3.3 Product Released and Chemicals of Concern

MDNR's Tanks Section regulates releases of "regulated substances" from USTs and ASTs used for the sale of petroleum products. "Regulated substances" are defined as

“petroleum, including crude oil or any fraction thereof, which is liquid at standard conditions of temperature and pressure, sixty degrees Fahrenheit and fourteen and seven-tenths pounds per square inch absolute, respective.” (Section 319.00 RSMo). This may include:

- Gasoline,
- Diesel/Light Fuel Oils,
- Jet Fuel,
- Kerosene, or
- Used Oil.

Knowing what was released can simplify the process of identifying relevant COCs.

Each of the products listed above is a mixture of numerous hydrocarbon compounds and additives whose physical and chemical properties and percent composition vary. The environmental behavior (mobility, persistence, and inter-media transport) of these products and any adverse environmental and human health effects depend on (i) the properties of the individual compounds, (ii) their concentration in the product, and (iii) their degradation by-products and analogous compounds. Table 5-2 presents the range and average weight percent of a few of the constituents of different products.

The MRBCA process focuses on a limited set of chemicals specific to various petroleum products that pose the greatest risks to human health and the environment. These are known as the **chemicals of concern (COCs)**. Table 5-1 lists the major products and the corresponding COCs for which the impacted soil and groundwater shall be sampled and for which target levels shall be developed. Figure 5-1 is a flowchart that can be used to identify COCs. Depending on the petroleum product released, soil and groundwater samples at a site must be sampled for the COCs indicated in Figure 5-1 using the analytical methods listed in Table 5-1. Excluding COCs or using analytical methods other than those specified in Table 5-1 is allowed only with prior approval of MDNR. For releases other than gasoline, samples with detectable levels of total petroleum hydrocarbon-diesel range organic (TPH-DRO) or total petroleum hydrocarbon-oil range organic (TPH-ORO) shall also be analyzed for the polynuclear aromatic hydrocarbons (PAHs) listed on Table 5-1. The intent here is to identify site-related PAHs, hence additional sampling may be necessary to distinguish between site-related and background PAHs.

If the release at a site can be identified as consisting of a single product based on release reports, free product analysis, or location of impacts (e.g. the bottom of a particular product tank), COCs for that product only need be analyzed. If the product spilled or released cannot be conclusively identified based on these methods, then COCs corresponding to all products known or suspected to have been stored at the site shall be included in the initial analysis. Once the product or the COCs have been identified, the list of parameters for which samples are analyzed may be modified accordingly.

If data collected in the past does not include all the suspected COCs at a site, additional sampling might be necessary to quantitatively evaluate the missing COCs. The need to do so will be determined on a case-by-case basis.

5.3.4 Interim Corrective Actions

Typical interim corrective actions include the excavation and off-site disposal of contaminated soil, removal of free product, soil vapor extraction, and pump and treat. Interim corrective actions performed at a site could have removed all or part of the product spilled or released. Therefore, soil and groundwater data collected prior to the completion of such activities might not be representative of current conditions and shall not be used in the site risk assessment. At such sites, additional soil and groundwater concentration data representative of current conditions shall be collected after the completion of the interim corrective action. Data collected prior to the completion of interim corrective action may be used to determine where additional data shall be collected.

The nature and magnitude of the spill or release shall be reported in MRBCA Report Form No. Tier 1-3.

5.4 SITE INFORMATION

The following information is necessary to complete the MRBCA evaluation:

- A site map,
- An understanding of ground surface conditions,
- Location of utilities on and adjacent to the site,
- On-site and nearby off-site groundwater use, and
- Regional hydrogeology and aquifer characteristics.

A brief discussion of each of the above items is presented below. Note that relevant site information can be obtained by various means, including (i) a site visit, (ii) review of engineering drawings showing the layout of the site, (iii) review of regional information, and (iv) review of files at MDNR related to the site or adjacent sites.

5.4.1 Site and Site Area Maps

A detailed site map of the facility showing property boundaries and the layout of past and current site features such as USTs, ASTs, piping, dispenser islands, sumps, paved and unpaved areas, canopy, station building, etc. shall be prepared. The map shall show, at least, the locations of (i) on-site monitoring wells (including those that have been abandoned, lost or destroyed), (ii) water wells (public and private), (iii) soil borings, (iv) soil vapor extraction wells, (v) soil excavation areas, and (vi) area of release (refer to Section 5.8). As appropriate, multiple maps showing these features may be prepared.

A site area map shall be prepared using United States Geological Survey (USGS) 7 ½

minute topographic maps as a base. The site location should be centered on the topographic map (cropping the maps as necessary to center the site), with the site's location clearly marked. Contour lines on the topographic map must be legible upon delivery to MDNR.

Site maps shall be made to scale, with a bar scale, and a north arrow. MDNR will reject maps that are not to scale or without a north arrow. Note that, in addition to the site map(s) discussed here, a land use map is also required (refer to Section 5.5.1).

These site maps are included as attachments to MRBCA Report Form No. Tier 1-1.

5.4.2 Ground Surface Conditions

Determine the portion of the site that is paved, unpaved, or landscaped. Note the type, extent, and general condition of the pavement, and describe the unpaved areas (e.g., vegetated, gravel, bare soil, etc.). Determine the direction in which the surface is sloping and note relevant topographic site features (e.g., swales, drainage ditches, etc.).

Ground surface conditions shall be reported in MRBCA Report Form No. Tier 1-2.

5.4.3 Location of Utilities On and Adjacent to the Site

Due to the potential for preferential flow of impacted groundwater and vapors into underground utility lines/conduits, a thorough assessment of potential and actual migration and impact of COCs to underground utilities must be performed. Utilities include, but are not limited to, phone lines, water lines, sanitary sewers, storm sewers, and natural gas lines. A combination of site observations, knowledge of buried utilities, and discussions with utility representatives and the site owner shall be used to determine the locations of site utilities. At a minimum, perform the following:

- Locate all underground utility lines and conduits within the area of known or likely soil and groundwater impact, both on-site and off-site, where the release may have migrated or may migrate in the future.
- Determine the direction of flow in the utilities (water, storm water, and sewage).
- Identify the utility lines/conduits on a base map that also shows the extent and thickness of free product, if any, and soil and groundwater contamination.
- Determine depth of the utility lines/conduits relative to the depth of groundwater. Seasonal fluctuations of the groundwater levels (relative to the depth of utilities) shall be carefully evaluated. Where such would assist in the evaluation and understanding of site conditions, a cross-sectional diagram shall be provided illustrating the depth to groundwater and the locations and depths of the utility lines/conduits. At a minimum, a cross-section diagram would be required at sites where deeper water bearing zones are used for drinking water and where utilities may be preferential pathways.
- Determine the types of materials used for lines/conduits (i.e., PVC, terra-cotta, concrete, steel, etc.) and backfill around the utilities.

- Determine any past impacts to utilities and whether any complaints have been previously filed with MDNR or the property owner.
- As appropriate, sample the utilities and vaults using either an explosimeter, PID, or organic vapor monitor (OVM) or by taking air samples. If explosive conditions are encountered, immediately inform the local fire department and MDNR (contact MDNR at (573) 634-2436).
- Where a utility is threatened, or where the possibility of an explosion exists, appropriate measures to eliminate fire, explosive, and vapor hazards must be undertaken immediately.

Information about utilities shall be reported in MRBCA Report Form No. Tier 1-2.

5.4.4 On-site Groundwater Use

The current and former site owners and operators should be interviewed to determine whether a water well is/was located on site. If a water well is identified, construction details of the well shall be obtained to the extent such are available. At a minimum, the total depth of the well, screen (if present) interval, and the use of water from the well shall be determined. If such a well is identified and is not currently in use or likely to be used in the future, it shall be properly abandoned in accordance with MDNR requirements, unless it is to be used for future sampling as part of a risk management plan for the site. In addition to water wells, dewatering wells on or adjacent to the facility shall also be identified.

Groundwater use and well construction details shall be reported in the narrative portion of the site check and site characterization reports (with well construction logs included as an appendix) and, as appropriate, on Form No. Tier 1-8.

5.4.5 Regional Hydrogeology and Aquifer Characteristics

Published literature, especially USGS publications and United States Department of Agriculture (USDA) soil surveys, and reports for any investigations conducted at adjacent or nearby release sites, shall be reviewed to determine regional hydrogeology, soil types, and aquifer characteristics. This evaluation shall be used to determine the type and depth of aquifers in the area and whether they are confined, semi-confined, or unconfined. General aquifer characteristics such as yield and total dissolved solids will help determine whether the groundwater ingestion exposure pathway is a concern. Regional information will assist the entity conducting the work to better understand site-specific soil and groundwater conditions.

A valuable source of regional hydrogeology and aquifer characteristic information is the Missouri Environmental Geology Atlas (MEGA) developed by MDNR in association with the Missouri Petroleum Storage Tank Insurance Fund (PSTIF). Data can be obtained from MDNR's Geological Survey & Resource Assessment Division at (573) 368-2101; the cost is \$25 for software only, or \$40 for software and training.

The review discussed above shall also locate surface water bodies (e.g., creeks, lakes, rivers, etc.), seeps, and springs within 500 feet of the site (unless MDNR requires a different distance based on site conditions) that could be or are affected by the site release. If a surface water body is identified and it is determined that it may be impacted by site-specific COCs, collect information regarding the type (perennial vs. intermittent), flow rate, flow direction, depth, width, and use of the surface water body. The water body must be identified on the area map discussed at 5.4.1. In karst areas, MDNR may require that the minimum search area radius be increased and the identification of springs, seeps, sink holes, and other karst features be included.

Hydrogeologic data shall be reported in MRBCA Report Form No. Tier 1-5.

5.5 ON-SITE AND OFF-SITE LAND USE AND RECEPTOR INFORMATION

Land use information is used to identify the (i) location and type of receptors, (ii) routes of exposure by which the receptors might be exposed to the COCs, and (iii) presence of any activity and use limitations (AULs) pertaining to the site. This information is critical in developing a site exposure model as discussed in Section 6.1. The following information shall be collected:

- Current land use,
- Potential future land use,
- Local ordinances and restrictions that affect land use and/or groundwater use,
- Water well survey, and
- Ecological receptor survey.

A land use and receptor survey covering a radius of 500 feet from the area of release will generally be adequate. At sites where the plume might be much longer due to the magnitude of the spill or other site-specific conditions, MDNR may require that the minimum survey radius be increased and will require submittal of a land use map covering the entire impacted and potentially impacted area.

5.5.1 Current Land Use

Identification of the use of the site and nearby properties is used to define potential on-site and off-site receptors that might be exposed to the COCs. There shall be no ambiguity about the current land use. A visual, on-site land use survey within a 500-foot radius (unless MDNR requires a different distance based on site condition) of the site shall be conducted. The survey shall clearly identify the following: schools, hospitals, residences (apartments, single-family homes), buildings with basements, day care centers, churches, nursing homes, and types of businesses. The map shall also identify surface water bodies, parks, recreational areas, wildlife sanctuaries, wetlands, and agricultural areas. The results of the survey shall be accurately documented on a land use map. Figure 5-2 is a sample land use map.

The land use map need not be drawn to an exact scale; an approximate scale will suffice in most cases. However, a north arrow is required on the land use map.

Land use shall be reported in MRBCA Report Form No. Tier 1-2 and the land use map as an attachment to the form.

5.5.2 Future Land Use

While it is a simple matter to determine the current land use and receptors, future land use and receptors might not be certain. Unless future land use is known and can be documented (e.g., via development plans, building permits, etc.), predictions of future use shall be based on local zoning laws and surrounding land use patterns. As appropriate, zone atlas and maps, aerial photographs, local planning offices, the US Bureau of the Census, community master plans, changing land use patterns, and interviews with current property owners can provide information with which future land use can be predicted. Proximity to wetlands, critical habitat, and other environmentally sensitive areas should also be considered in predicting future land uses.

5.5.3 Leased Property and Existing Restrictions

If a property being evaluated is leased, the current or immediate future owner of the property, in consultation with the entity leasing the property must confirm the future land use. This would then be a basis for determining the reasonable future land use to be used in the RBCA evaluation. Information submitted to MDNR pertaining to future land use that is not attributable to the current or immediate future property owner and is not accompanied by confirmation from this person will not be accepted.

Evaluations of current and future use of a site should include a determination as to whether existing activity and use restrictions (i.e., AULs) apply to the site. If existing restrictions are in place, these should be taken into account in evaluating current and reasonably anticipated future exposure pathways at the site.

When the future land use cannot be reasonably predicted, assume future land use is residential. Note that, when the future land use cannot be reasonably predicted or supported by appropriate and adequate documentation, MDNR may require that the future land use be designated residential if more than 50% of adjacent properties are currently residential.

Land use shall be reported in MRBCA Report Form No. Tier 1-2.

5.5.4 Water Well Survey

A water well survey shall be conducted to locate all public water supply wells within an approximately one-mile radius of the site and all private water wells within an approximately quarter-mile radius of the site. Information sources include the USGS, the Missouri Environmental Geology Atlas (available from GSRAD), water system

operators, and interviews with local residents. In areas where private water use wells are likely, MDNR may require that a door-to-door survey of businesses and residents within a quarter-mile radius of the site be conducted. To the extent such information is available, well characteristics including age, depth to water and total well depth, water use, screen (if present) interval, construction, depth of casing(s), and mode of operation (continuous vs. intermittent) shall be documented.

Groundwater use and well construction details shall be reported in the narrative portion of the site check or site characterization report and, as appropriate, on RBCA Report Form No. Tier 1-8.

5.5.5 Ecological Receptor Survey

Ecological receptors include both specific species and general populations of flora and fauna and their habitats, including, but not limited to, wetlands, surface water bodies, sensitive habitats, and endangered species. The checklist included as Attachment A to this section must be completed for each site, except those where initial sampling indicates concentrations of COCs are below the DTLs and the site poses no obvious threat to ecological receptors. If the answer to any of the questions on the checklist at Attachment A is yes, then the Attachment B checklist must also be completed. These checklists are located at the end of this chapter. Completion of either checklist might require that the area within an approximately 500-foot radius of the site be visually surveyed for specific ecological receptor criteria as identified on the checklists. MDNR will require that such a survey be conducted if the checklists cannot be completed based on existing information. For any site where ecological receptors might be affected by contamination from a site being evaluated under this guidance, as determined by completion of the checklists in Attachments A and B, consultation with MDNR will be required.

Refer to Section 6.6 for further information regarding ecological receptor evaluations.

5.6 VADOSE ZONE SOIL CHARACTERISTICS

Vadose zone soil is the media through which COCs migrate to groundwater and vapors move upward to the ambient air or into an enclosed space. The following vadose zone parameters and their variability across the impacted area significantly affect the movement of chemicals through vadose zone soil:

- Thickness of vadose zone and depth to groundwater,
- Porosity,
- Water content,
- Fractional organic carbon content, and
- Bulk density.

In developing the DTLs and Tier 1 RBTLs, MDNR assigned conservative values to these parameters as shown in Table B-4. For Tier 2 and Tier 3 risk assessments, these parameters may be assigned site-specific values based on data collected from the site.

In the event that circumstances at a site are such that the geotechnical properties discussed below cannot be determined because of sampling limitations, the evaluator shall use appropriate, justifiable literature values. Where such literature values cannot be found or do not exist, the evaluator shall contact MDNR's Tanks Section.

5.6.1 Thickness of Vadose Zone and Depth to Groundwater

The thickness of the vadose zone can be determined based on information presented on boring logs for the site and is representative of the distance from the ground surface to the depth at which the water table is encountered, not including the thickness of the capillary fringe. Depth to groundwater is used in estimating the vapor emissions from groundwater and to determine the vadose zone dilution attenuation factor.

For sites where the water table fluctuates considerably, the available data shall be evaluated to determine whether the fluctuations are seasonal or represent a consistent upward or downward regional trend. For sites with seasonal fluctuations, the average depth to groundwater and the average thickness of the vadose zone will be used (as determined by groundwater level measurements obtained on at least a quarterly basis over one year). At sites with a consistent upward or downward water level trend, the most recent data will be used to estimate the depth to groundwater.

Generally, collection of samples for the four parameters discussed below will require the advancement of more than one boring or probe, depending on site conditions and recovery volumes. Ultimately the number of borings or probes advanced in attempting to obtain adequate samples for these parameters will be a site-specific decision of the driller and environmental consultant based on professional experience and judgement. If samples cannot be collected, literature values (including values from samples collected in the field at nearby sites having very similar lithologic and geologic characteristics) may be used with adequate documentation and justification.

Note that in situations where undisturbed samples cannot practically be collected but disturbed samples can be, samples should be collected for those parameters not requiring an undisturbed sample (i.e., fractional organic carbon, gravimetric water content, and particle density [a value required for determining porosity]).

5.6.2 Dry Bulk Density (g/cc)

Dry bulk density is the dry weight of a soil sample divided by its field volume. An accurate measurement of bulk density requires determining the dry weight and volume of an undisturbed sample. An undisturbed soil core sample may be collected using a Shelby tube, a thin-walled sampler, or an equivalent method. The sample must not be disturbed prior to laboratory analysis.

Dry bulk density is estimated using the American Society for Testing and Materials (ASTM) Method D2937-94, "Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method." At sites where multiple, widely differing soil types occur in the

vadose zone, one sample must be collected from each distinct, predominant soil type. At such sites, the percentage of each soil type relative to the overall volume of the vadose zone should be considered in collecting samples for bulk density. Where soil at a site is homogenous or nearly so, a single sample for bulk density analysis will generally suffice.

5.6.3 Porosity (cc/cc-soil)

Porosity is the ratio of the volume of voids to the volume of the soil sample. Many laboratories use dry bulk density and specific gravity to calculate porosity using the following:

$$n = 1 - \rho_b / \rho_s \quad (5-1)$$

where,

- n = porosity (cc/cc)
- ρ_b = dry bulk density (g/cc)
- ρ_s = specific gravity or particle density (g/cc).

Thus, specific gravity and dry soil bulk density are needed to estimate porosity.

The “Standard Test Method for Specific Gravity of Soil,” ASTM Method D854, may be used to determine specific gravity. If specific gravity or particle density is not available, then 2.65 g/cc can be assumed for most mineral soils. Note, however, that use of this value must be justified.

If a site-specific porosity value cannot be determined, literature values consistent with the site lithology may be used, provided the source(s) of the value(s) is cited and appropriately justified. Where the total and effective porosities differ, the effective porosity value must be used.

5.6.4 Volumetric Water Content/Moisture Content (cc/cc)

Volumetric water content is the ratio of the volume of water to the volume of soil. ASTM Method D2216-92, “Standard Test Method for Laboratory Determination of Water [Moisture] Content of Soil and Rock,” is a gravimetric oven drying method that may be used to measure the water content of vadose zone soils. However, the water content value used in most models is the volumetric water content. Hence, if a gravimetric method is used to measure water content, the following conversion equation should be used to obtain the volumetric value:

$$\theta_{wv} = \theta_{wg} \times \frac{\rho_b}{\rho_l} \quad (5-2)$$

where,

- θ_{wv} = volumetric water content (cc water / cc soil)
- θ_{wg} = gravimetric water content, typically reported by the laboratory (g of water / g of soil)
- ρ_b = dry bulk density (g of dry soil/cc of soil)
- ρ_l = density of water (g/cc).

Multiple samples from across the site and at varying depths should be analyzed for water content to estimate a representative water content value for the vadose zone. Each soil sample analyzed for one or more of the applicable COCs must also be analyzed for water content (at sites where multiple samples from multiple depths are analyzed for COCs on a dry weight basis, additional samples solely for analysis of water content might not be necessary). In addition, water content values representative of each of the lithologic units that comprise the vadose zone shall be determined. Note all soil COC concentration data must be reported on a dry weight basis.

5.6.5 Fractional Organic Carbon Content in Soil (g-C/g-soil)

Fractional organic carbon content is the weight of organic carbon in the soil divided by the weight of the soil and is expressed either as a ratio or as a percent. Organic carbon content must be determined using soil samples not impacted by petroleum or other anthropogenic chemicals. Therefore, a soil boring away from the impacted area but within soil that is the same as, or very similar to, that found at the site will have to be drilled to collect fractional organic carbon content. Prior to collecting the sample, a PID reading shall be taken and observations made to confirm that the sample has not been impacted by petroleum products or other anthropogenic contaminants.

At a minimum, samples representative of the vadose and saturated zones shall be collected for fractional organic carbon content analysis. At sites where the vadose zone consists of several different soil types, each predominant soil type must be sampled. Vadose zone samples to be analyzed for fractional organic carbon content should be collected from a boring/probe by combining subsamples from at least three separate points between a depth of at least three feet below the ground surface and the top of the water table and combining the subsamples to create one composite sample for laboratory analysis. An additional composite sample should be collected to represent fractional organic carbon content in the saturated zone, with the sample comprised of at least two subsamples, one collected immediately below the top of the saturated zone and the second collected at least three feet below the top of the groundwater table.

For sites where subsurface soil types vary significantly from one part of the site to another, soil samples from the vadose and saturated zones should be collected at two or more boring or probe points located to represent the differing soil types. As appropriate, the resulting fractional organic carbon content can then be averaged to establish a fractional organic carbon content for the site as a whole.

Fractional organic carbon content may be estimated using the Walkley Black Method (Page et al., 1982). However, some labs may not be familiar with this method. An alternative, though less preferred, method is ASTM Method 2974 (Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils) that measures the organic matter content of a sample. When using Method 2974, the result must be divided by 1.724 to get fractional organic carbon content. If the laboratory results are reported as a percent, fractional organic carbon content may be obtained by dividing by 100.

The vadose zone characteristics shall be reported in MRBCA Report Form No. Tier 1-10.

5.7 SATURATED ZONE CHARACTERISTICS

COCs that reach the water table primarily travel horizontally in the saturated zone. Vertical transport is also possible when a vertical gradient exists between shallow and deeper saturated zones. Saturated zone characteristics that determine the travel time for the COCs as well as the travel direction include:

- Horizontal hydraulic conductivity,
- Hydraulic gradients (magnitude and direction),
- Saturated zone soil characteristics (fractional organic carbon content, porosity, and bulk density), and
- Occurrence and rate of biodegradation.

Of the four characteristics mentioned above, the most important aquifer properties are horizontal hydraulic conductivity and hydraulic gradient. Each of these is discussed below, along with a brief discussion regarding the capillary fringe.

Note that quantification of the above characteristics will be required only at sites where it is necessary to quantify the movement of water or the COCs by using a model. If a quantitative evaluation is not necessary, a qualitative understanding of these parameters is sufficient.

5.7.1 Hydraulic Conductivity (cm/sec)

Hydraulic conductivity is the discharge of water per unit area per unit hydraulic gradient in a subsurface formation. Reliable estimates of site-specific hydraulic conductivity can be obtained by pump tests or slug tests. In the absence of these tests, literature values corresponding to the type of soil in the saturated zone may be used. When a literature value is used, adequate reference and justification for the value chosen must be provided. When using literature values, all predominant soil types composing the saturated zone must be considered. Hydraulic conductivity may also be estimated based on the grain size distribution of the porous formation.

5.7.2 Hydraulic Gradient (cm/cm)

The magnitude and direction of the hydraulic gradient is estimated by comparing water levels measured in monitoring wells across a site. A contour map shall be prepared, either manually or using a computer program, using field measured water level data. These contour maps can be used to estimate both the direction and magnitude of the hydraulic gradient. When drawing the contour maps, care shall be taken to ensure that measurements from monitoring wells screened in the same interval or hydrologic unit are used. For sites where wells are screened in multiple zones, a contour map for each zone shall be developed. For sites that have seasonal variation in hydraulic gradient and/or

predominant flow direction, estimate the average hydraulic gradient for each season and each flow direction.

At sites where a “deeper” groundwater zone is used as a water supply, vertical gradients must also be determined via a comparison of water levels in adjacent wells screened in different intervals. MDNR will consider exceptions to this requirement on a site-specific basis.

Hydraulic conductivity and gradient shall be reported on MRBCA Form No. Tier 1-5.

5.7.3 Thickness of Capillary Fringe (cm)

The capillary fringe is the zone immediately above the saturated zone where capillary attraction causes upward movement of water molecules from the saturated zone into the soil above. This zone is distinct in that it has characteristics of both the vadose and saturated zones. For purposes of the MRBCA process, the thickness or height of the capillary fringe must be measured or a default value used. Because accurate field measurement of the thickness of the capillary fringe can be difficult, literature values based on the soil type immediately above the water table may be used to assign a site-specific value for the capillary fringe thickness.

5.7.4 Saturated Zone Soil Characteristics

The saturated zone soil characteristics include fractional organic carbon content, porosity, and bulk density. These parameters are required to estimate the retardation factor that “slows” the movement of chemicals within the saturated zone and are also useful when estimating future concentrations using models that include a finite source and/or biodecay. The laboratory methods to measure these parameters have been discussed in Section 5.6.

Saturated zone soil characteristics shall be reported in MRBCA Report Form No. Tier 1-10.

5.7.5 Occurrence and Rate of Biodegradation

By measuring several indicators (chemical concentrations, geo-chemical indicators, electron acceptors, microorganisms, carbon dioxide, etc.), the occurrence of natural attenuation can be measured at a site. These indicators can be broadly classified into three groups: (i) primary, (ii) secondary, and (iii) tertiary lines of evidence. The collection of biodegradation data need not occur at every site. Generally, this data will be required only when biodegradation is a principal element of the RMP. Data collected under each line of evidence is used to qualitatively evaluate the occurrence of biodegradation.

- The primary line of evidence is developed by demonstrating that reductions in chemical concentrations are occurring at a site via the evaluation of COC concentrations in groundwater. The primary line of evidence is best determined

by (i) plotting concentrations of COCs as a function of distance along the plume center line, (ii) plotting concentrations of COCs in each well as a function of time, and (iii) comparing COC concentration contour maps at various times.

- The secondary line of evidence involves measuring geo-chemical indicators including (i) dissolved oxygen, (ii) dissolved nitrates, (iii) manganese, (iv) ferrous iron, (v) sulfate, and (vi) methane. These indicators shall be measured in at least three wells located along the plume flow line. The wells must be located to represent conditions at (i) a background or upgradient location, (ii) an area within the plume near the source, and (iii) an area within the plume downgradient of the source. Developing a secondary line of evidence is necessary when the primary line of evidence is inconclusive, or when such information is necessary to design a remedial system (e.g., the addition of oxygen).
- Developing a tertiary line of evidence involves identifying and quantifying microorganisms within and near the plume via the performance of microbiological studies. A tertiary line of evidence is seldom developed at petroleum hydrocarbon impacted sites. MDNR has found that, in most cases, microbial populations at sites having petroleum contamination are adequate.

The commonly used methods to estimate biodegradation include (i) mass balance analysis for expanding, stable, or shrinking plumes and (ii) plume concentration vs. distance plots.

At most UST/AST sites, the development of secondary and tertiary lines of evidence is usually not necessary. However, at most sites, groundwater sampling data should be plotted to evaluate temporal trends. These trends can be used to determine whether the plume is expanding, stable, or decreasing. MDNR will require that the groundwater plume be stable or decreasing prior to issuing a No Further Action (NFA).

Secondary line of evidence natural attenuation data shall be reported in MRBCA Report Form No. Tier 1-9.

5.8 DISTRIBUTION OF COCs IN SOIL

The objective of soil characterization is to (i) delineate the extent of site-related COCs, (ii) compare representative concentrations, or, for surficial soil at a residential site, maximum concentrations, for each complete pathway to the target levels, and (iii) define the area of release in the event that fate and transport modeling is necessary.

Within the MRBCA program, distinction is made between surficial soil and subsurface soil. Surficial soil is defined as soil extending from the surface to 3 feet below the ground surface (bgs). Subsurface soil is defined as soil that extends from 3 ft bgs to the top of the water table. A key difference between surface and subsurface soil is that, for surficial soil, the direct contact pathway (ingestion, dermal contact, and inhalation of vapors and particulates) is considered complete for both the residential and non-

residential receptors. For the subsurface soil, this pathway is considered incomplete for the subsurface soil except for the construction worker who may be involved in excavation activities below the surficial zone and hence come in direct contact with subsurface soil. In fact, for the construction worker, no distinction is made between the surface and subsurface soil.

Because of the differences in exposure pathways for surface and subsurface soils, an adequate number of soil samples from each zone has to be collected to meet the soil characterization objectives listed above. Surficial soil (as well as subsurface soil) may include fill material - the distinction between surface and subsurface soil is one of depth rather than composition.

Note that, when volatile organic compounds (VOCs) are COCs at a site, soil samples for VOC analysis must be collected and analyzed in accordance with SW-846 Method 5035.

The following discussion is intended to assist the person conducting the work in determining where soil samples shall be collected.

5.8.1 Delineation Criteria, Area of Release, and Point of Release

The underlying basis of delineation is that chemical impacts at a site should be delineated to levels that are protective of human health and the environment. To the extent that COC concentrations protective of human health and the environment depend on the complete routes of exposure, the delineation criteria depend on land use. Because delineation is necessary to develop risk-based target levels, some iteration in delineation sampling may be necessary.

The delineation criteria are the lowest MRBCA Tier 1 RBTLs for each media. For soils these levels depend on the land use (residential vs. non-residential). Note that target levels for surface soils (0-3 ft bgs) are different than target levels for subsurface soils (>3 ft bgs). Note also that, when delineation criteria are lower than the Required Reporting Limits (RRLs) listed in Table 5-3, the RRLs or, if lower, the detection limits of the laboratory conducting the analysis, shall be considered as the delineation criteria.

As applicable, the Tier 1 values in Table 7-1(a), 7-1(b), 7-1(d), or 3-1 may be used as delineation criteria. If the Tier 1 target levels change, MDNR may adjust the delineation criteria.

To determine the applicable delineation criteria at a site the following three steps are necessary:

Step 1: Develop a land use map and determine what land uses (residential or non-residential) apply to on and off-site properties (refer to Sections 5.5.1 and 5.5.2, and Figure 5-2).

Step 2: Determine whether the groundwater ingestion pathway is complete (under both

current and reasonably anticipated future use of the property) for the zones where groundwater is or will be impacted (refer to Section 6.3).

Step 3: Based on the above steps, select soil delineation levels for the COCs listed in Table 5-1 that are applicable to the site.

As discussed in Section 5.3.3, COCs depend on the product released. While, typically benzene, methyl tert-butyl ether (MTBE), and total petroleum hydrocarbon-gasoline range organic (TPH-GRO) will be the primary drivers, delineation is required for all applicable COCs.

A few examples for determining delineation criteria are presented below:

- If the land use both on-site and off-site is non-residential, use non-residential delineation criteria.
- If the land use both on-site and off-site is residential, use residential delineation.
- If either the on-site or the adjacent off-site land use is residential, use residential delineation criteria.

Once the delineation criteria have been established, the number of samples to be collected horizontally and vertically depends on the area of release and the point of release. These terms are defined below:

Area of Release: The vadose zone area through which petroleum product migrated from the point of release to the capillary fringe and the water table below. In the area of release, COC concentrations are elevated in the vadose zone below the point of release and laterally where the petroleum migrated through the soil.

Point of Release: This is the specific location within the area of release at which petroleum product was released to the environment. Typical points of release include holes in USTs, pipe joints or connections, pump island connections, AST spill drains, and fill ports.

Professional judgment is frequently required in determining the point of release.

5.8.2 Determining Area of Release

Step 1: Initially, review site information and site history to make reasonable judgments about the area(s) of release. Within each area of release, identify the point of release and locate a boring at this point. If the point of release within an area cannot be determined, locate the boring near the center of the release area. If the point of release is an active tank or piping run, locating a boring immediately adjacent to the tank or piping might not be practical for safety reasons. In such cases, locate the point of release boring as close to the tank or piping run as is safely possible.

Step 2: From the point of release identified in Step 1, step out 25 feet in four opposing

directions (e.g., south, north, east, west or southeast, northwest, northeast, southwest, etc.) and install 4 more borings. While installing each boring, screen soil samples continuously with a PID to determine whether or not the boring is within the area of release. This step will require professional judgment of field screening results (e.g., PID readings, evidence of soil staining, perception of odors, etc). If the results of field screening indicate that one or more of the borings are still within the area of release, step out in the same direction another 25 feet from the point of release boring (i.e. it will not be necessary to step out in all directions) and install another boring, screening the core samples as the boring is advanced. Continue to step out in this manner until borings are outside the release area in all directions. Using this protocol, some borings will be within the area of release and some will not. Note that, depending on the distance from the point of release to the edge of the area of release, additional borings might be needed to provide data for the areas between the step-out borings. The number of soil samples collected in each boring shall be determined as follows.

Soil Sampling at the Point of Release

To determine the vertical extent of COCs at each boring or probe advanced at a point of release, four soil samples shall be collected for laboratory analysis as follows:

- In each boring or probe, continuously conduct field screening (using a PID for releases of gasoline and PID and sight and smell for heavier petroleum products). Continue field screening, below the water table if necessary, until PID readings at two consecutive intervals are at or below background levels.
- Collect one soil sample from the 0 to 3' interval (at the point of release, this sample is collected regardless of field screening results).
- Collect one sample from the interval between 3' and the top of the water table, choosing the sample from the interval where field screening indicates COC levels are at their maximum.
- Collect one sample at the interface of the vadose and saturated zones i.e., within the capillary fringe.
- Collect one sample below the water table from the interval where field screening indicates COC levels are at their maximum.

At sites where bedrock is encountered before reaching the water table, collect a sample at the soil/bedrock interface.

Borings Away from Point of Release but within Area of Release

Borings or probes advanced away from the point of release but within the area of release should be sampled as discussed above for the point of release, except that a sample need not be collected from the 0 to 3' interval unless field screening indicates COC levels are elevated in the interval.

Borings Outside the Area of Release

Soil samples for laboratory analysis will be collected from soil borings and borings advanced for monitoring wells outside of the area of release as follows:

- Collect one sample at the interface of the vadose and saturated zones.
- Collect one sample below the water table from the interval where field screening indicates COC levels are at their maximum.
- Collect one sample from the interval between 3' and the top of the water table only if field screening indicates that elevated COC levels exist in the interval (contamination detected in this zone generally means the boring remains within an area of release).

At sites where bedrock is encountered before reaching the water table, collect a sample at the soil/bedrock interface.

***Surficial soil data shall be reported in MRBCA Report Form No. Tier 1-6.
Subsurface soil data shall be reported in MRBCA Report Form No. Tier 1-7.***

All soil sampling must be performed in accordance with the following guidelines and procedures:

- Soil borings must be extended to the water table or to a specified depth, not less than 20 ft bgs, if water is not encountered and impacts are not observed; this assumes one does not encounter refusal at a shallower depth.
- Samples shall be collected at either 2 ft or 5 ft intervals (no more than 5 ft) and field screened (this refers to continuous soil sampling and the length of the samples).
- Soil borings shall be logged and samples for laboratory evaluation collected in accordance with the methods approved by MDNR (see Figures 5-3(a) and (b) for boring logs).
- All samples must be adequately preserved according to the requirements of the laboratory analyses and extracted within the holding times of each particular analysis.
- Sample analyses must be conducted in accordance with current MDNR recommended analytical requirements and U.S. EPA Office of Solid Waste and Emergency Response SW846 Methods.
- Adequate quality assurance/quality control (QA/QC) procedures must be utilized to ensure sample quality and integrity. QA/QC samples shall include surrogate and spike recovery and trip blanks whenever possible. The samples must not be cross-contaminated by drilling fluid or by the drilling and sampling procedures. All sampling equipment must be decontaminated utilizing U.S. EPA and standard industry protocols.

All boreholes and probes greater than ten (10) feet in depth must be abandoned in accordance with 10 CSR 23-4.080(6), as follows:

- Remove any temporary pipe (as in the case of a piezometer or temporary monitoring well) and fill the bore hole (or probe hole, auger hole, etc.) from total depth to at least ten (10) feet from the surface using approved grout. The remainder of the bore hole (i.e. top ten feet) must be filled with uncontaminated compacted native material or grout.

5.9 DISTRIBUTION OF COCs IN GROUNDWATER

An adequate number of groundwater samples shall be collected to definitively delineate the extent of dissolved contaminant plumes in all directions and to allow representative COC concentrations to be calculated based on the exposure model. Soil source delineation should serve as a guide in choosing the location of monitoring wells.

5.9.1 Delineation of Groundwater Contamination

The delineation criteria for groundwater depend on whether the groundwater pathway for ingestion is complete or incomplete based on consideration of current and potential future ingestion of the groundwater. Where the groundwater pathway for ingestion is complete, delineation criteria will be the lower of (i) the maximum contaminant levels (MCLs) (in the absence of MCLs, risk-based concentrations that assume ingestion of groundwater and inhalation of vapors due to indoor water use), and (ii) land use-dependent concentrations protective of indoor inhalation.

For groundwater where the groundwater ingestion pathway is incomplete, the delineation criteria are based on the protection of indoor inhalation. The indoor inhalation-protective values depend on whether the land use is residential or non-residential.

Delineation of groundwater contamination should be in accordance with the following:

- At sites where groundwater is, or is reasonably likely to be, used as a source of drinking water, investigations must delineate the extent of groundwater contamination to the applicable MCLs or other relevant standards protective of drinking water or the standards protective of indoor inhalation of vapors, whichever are lower
- If the groundwater ingestion pathway is incomplete, at both residential and non-residential sites, investigations must delineate groundwater contamination to the groundwater target levels protective of land use-specific indoor inhalation.

5.9.2 Groundwater Sampling

If groundwater has been contaminated by COCs, temporary sampling points may be used to screen for groundwater contamination and to assist in determining the optimal location of monitoring wells. A sufficient number of monitoring wells shall be installed to fully define the groundwater plume and allow the direction of groundwater flow to be determined. Monitoring wells must be installed in accordance with state laws, 10 CSR 23-4.010 through 10 CSR 23-4.080, and the following guidelines and procedures:

- An adequate number of monitoring wells must be installed to sufficiently delineate the horizontal and vertical extents of the groundwater plume and the direction of groundwater flow. At a minimum, one monitoring well must be installed in the source area, one upgradient of the source area, and another downgradient of the source area.
- Well placement and design shall consider the concentration of COCs in the source area and the occurrence of non-aqueous phase liquids (NAPLs) at the site.
- Well casing and screen materials must be properly selected. The top of the screened interval must be set at least 2-3 feet (preferably 5 feet) above the water table, unless the water table is within 3 feet of the ground surface.
- Wells must be properly developed and gauged after installation.
- A site survey must be conducted to establish well elevations and, by that, groundwater elevations. Based on the groundwater elevations, groundwater flow direction and gradient shall be determined and plotted on a map of the site.

Groundwater samples must be collected in accordance with the following guidelines and procedures:

- Monitoring wells must be purged an adequate number of well volumes prior to collecting a sample. The use of no-purge or low purge sampling techniques requires the pre-approval of MDNR.
- Samples must be collected utilizing US EPA approved methods and equipment.
- Samples must be adequately preserved according to the requirements of the laboratory analyses and extracted within the holding times of each particular analysis. Water samples to be analyzed for MTBE or the other oxygenates listed in Table 5-1 must be preserved with trisodium phosphate dodecahydrate (TSP).
- Sample analyses must be conducted in accordance with current MDNR analytical requirements and US EPA Office of Solid Waste and Emergency Response SW846 Methods. Refer to Table 5-1 for a listing of the required analytical methods.
- For samples requiring preservation by refrigeration, the chain of custody form for the samples must indicate the temperature at which the samples were received by the laboratory. MDNR may reject data for samples received by the laboratory at temperatures above 4°C (+/- 2°C).
- Adequate QA/QC procedures must be utilized to ensure sample quality and integrity. QA/QC samples shall include surrogate, spike recovery, field blanks,

and trip blanks. All sampling equipment must be decontaminated using US EPA and industry standard protocols.

- A chain of custody form must accompany all samples. A copy of the completed chain of custody must be submitted with all laboratory analytical reports. MDNR will not accept laboratory data that is not accompanied by a corresponding chain of custody.
- In most cases, for the first year after well installation, quarterly samples will be required. Subsequent monitoring should be designed by the consultant and proposed to MDNR as part of a site characterization or risk management plan, with a defined objective and timeframe. Sampling frequency may be reduced only with prior MDNR approval.

5.9.3 Determination of Plume Stability

To assess plume stability, groundwater monitoring must be conducted for a period of time sufficient to show a reliably consistent trend in contaminant concentrations. For the MRBCA process, such trend must be apparent over a monitoring period of one to three years, with samples collected on at least a quarterly basis. The default assumption is that two years of data will be necessary to make a determination of plume stability, however, in cases where one year of monitoring is sufficient to demonstrate a clearly declining or stable plume, no further monitoring will be required. In some cases where two years of monitoring does not clearly show a stable or declining plume, additional data may be required. Greater than three years of monitoring without a conclusion of stability would indicate that the plume is not stable.

Groundwater monitoring for the purpose of evaluating plume stability must be conducted under a work plan approved by MDNR.

Groundwater data shall be summarized in MRBCA Report Form No. Tier 1-8.

5.10 SURFACE WATER AND SEDIMENT SAMPLING

MDNR may request the collection of surface water samples when site investigation data shows or suggests that COCs have migrated to a surface water body. Such sampling must consider the representativeness of the samples with regard to the flow conditions. Water samples shall be collected both upstream and downstream of each groundwater discharge point. If one or more discrete discharge points cannot be identified even though the data indicates that contaminated groundwater is discharging to surface water, the point of discharge shall be determined based on data pertaining to groundwater flow direction and the horizontal, lateral, and vertical extent of the plume.

In addition, the collection of sediment samples may be required by MDNR if warranted by site conditions. If site investigation data shows or suggests that contaminated groundwater is discharging to a surface water body, sediment samples must be collected

from the affected surface water body. The evaluator shall compare the sediment sample data with sediment standards protective of human health and ecological receptors that can be obtained from literature (refer Section 6.6) or develop site-specific levels. The latter would be considered a Tier 3 activity and would require a pre-approved work plan. Refer to Section 6.4 for further guidance regarding the evaluation of surface water.

5.11 SOIL VAPOR SAMPLING

For sites where soil and/or groundwater concentrations exceed the Tier 1 RBTLs for the vapor migration to indoor air pathway, soil vapor monitoring can be conducted at Tier 2 to quantify COC concentrations in the vapor phase in soil. To do so, Tier 2 soil vapor SSTLs must be generated as discussed in Appendix C. The measured concentrations are then compared to the SSTLs. If these levels are exceeded, risk management can be conducted to meet the SSTLs or a Tier 3 evaluation may be conducted. Refer to Appendix C for information regarding soil vapor monitoring and development of Tier 2 SSTLs for soil vapor.

5.12 LABORATORY QA/QC

Laboratory analytical data must be accompanied by QA/QC sample results. The required QA/QC samples include a method blank, a laboratory control sample, a matrix spike, and a duplicate/spike duplicate. Instrument performance samples such as internal standard and surrogate recovery samples must be included in the data package. Laboratories having National Environmental Laboratory Accreditation Program (NELAP) accreditation need not submit full internal QA/QC data packages with their analytical data, however the above mentioned QA/QC sample data must be submitted.

The laboratory must ensure that the portions of the chain of custody form relevant to the laboratory are completed and that the completed chain of custody form accompanies all data packages.

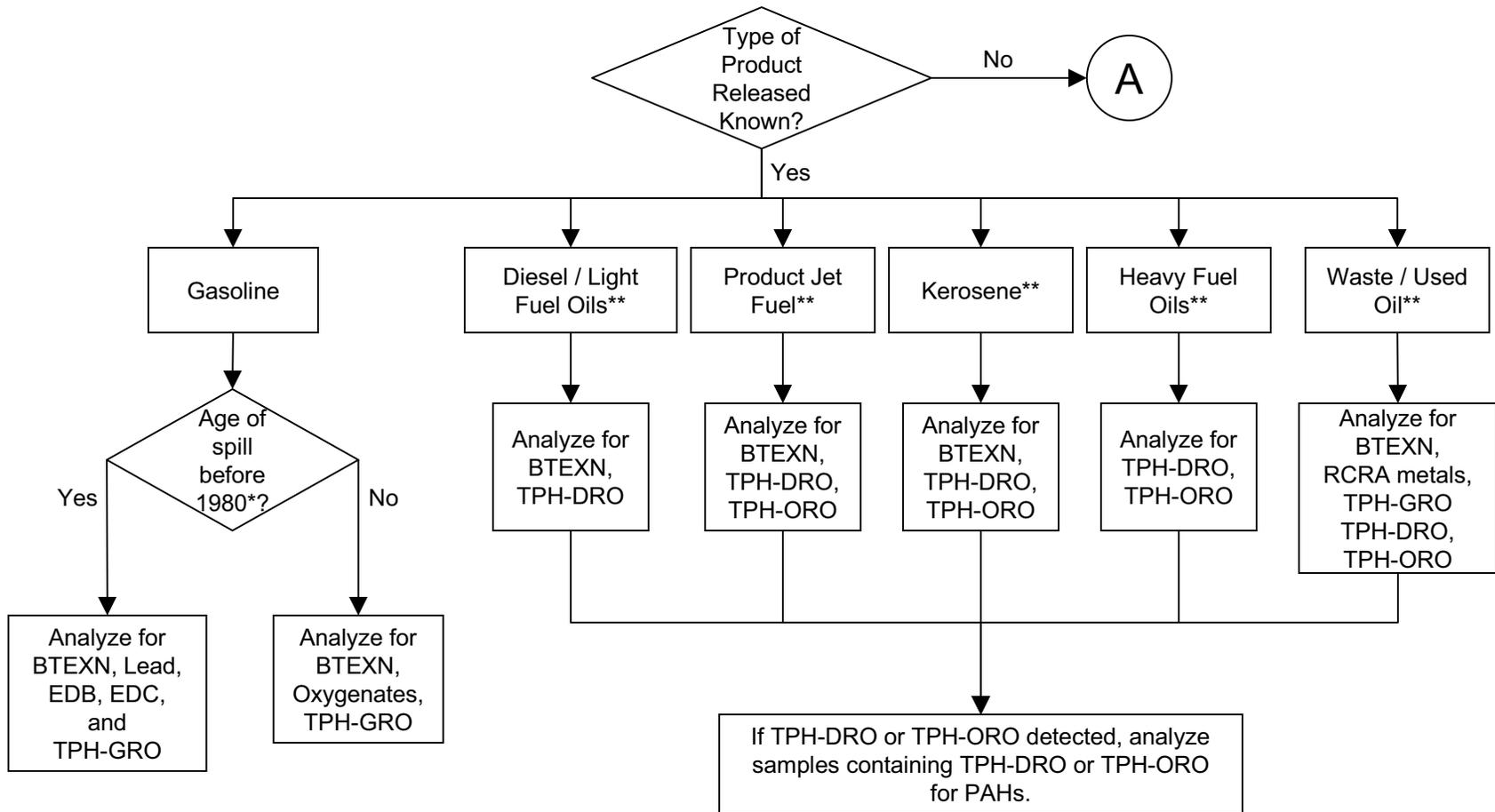
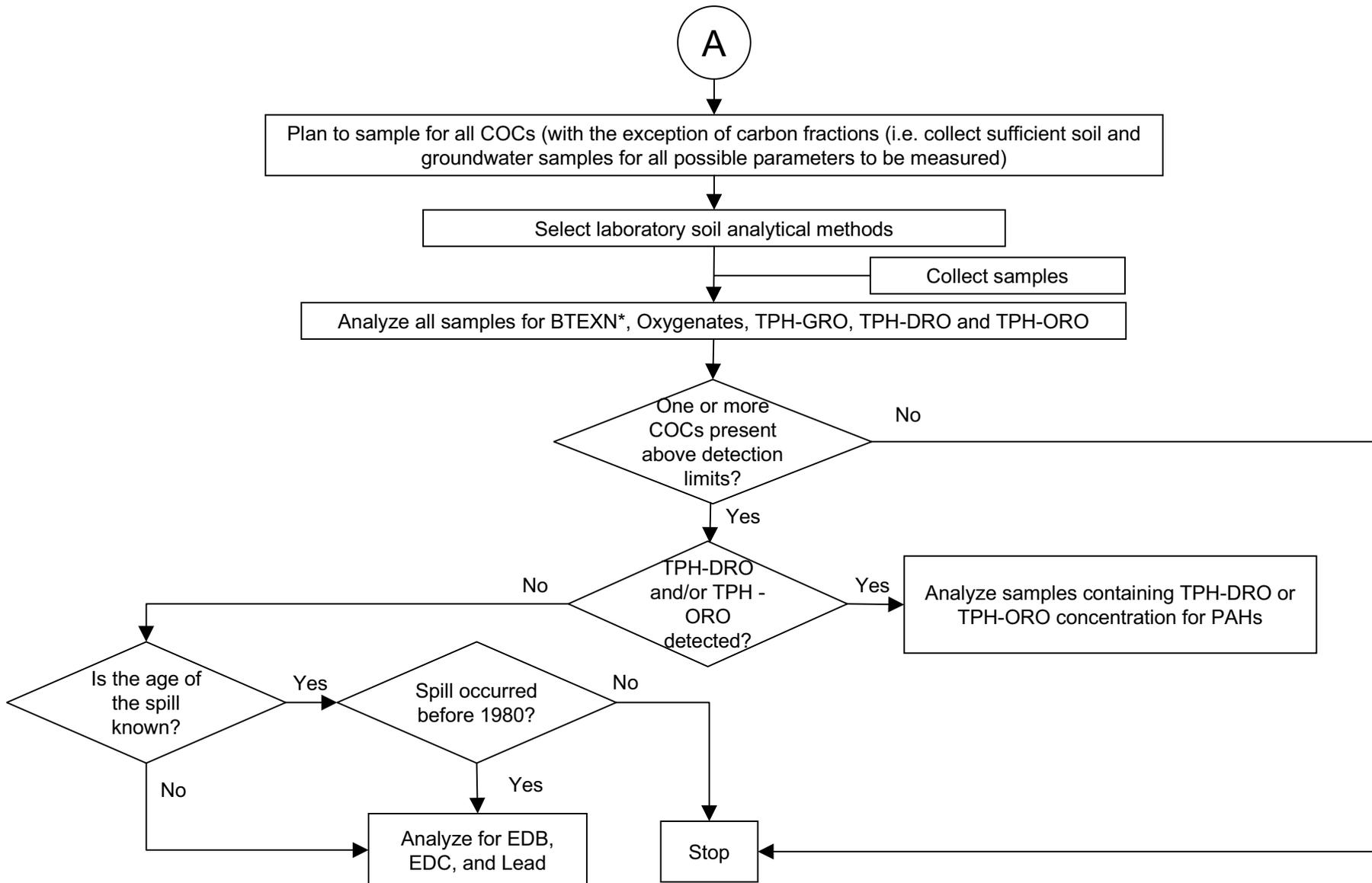


Figure 5-1. Chemicals of Concern Selection and Analysis (Page 1 of 2)

Notes:

*: If the age of the spill is unknown it should be assumed that the spill was prior to 1980, unless site information suggests otherwise (i.e. station operation began only in 1990).

** : Sufficient sample volume should be collected for these products to allow for the possibility of PAH analysis.



* Benzene, toluene, ethylbenzene, xylenes, and naphthalene

Figure 5-1. Chemical of Concern Selection and Analysis (Page 2 of 2)

Figure 5-2. An Example of a Land Use Map

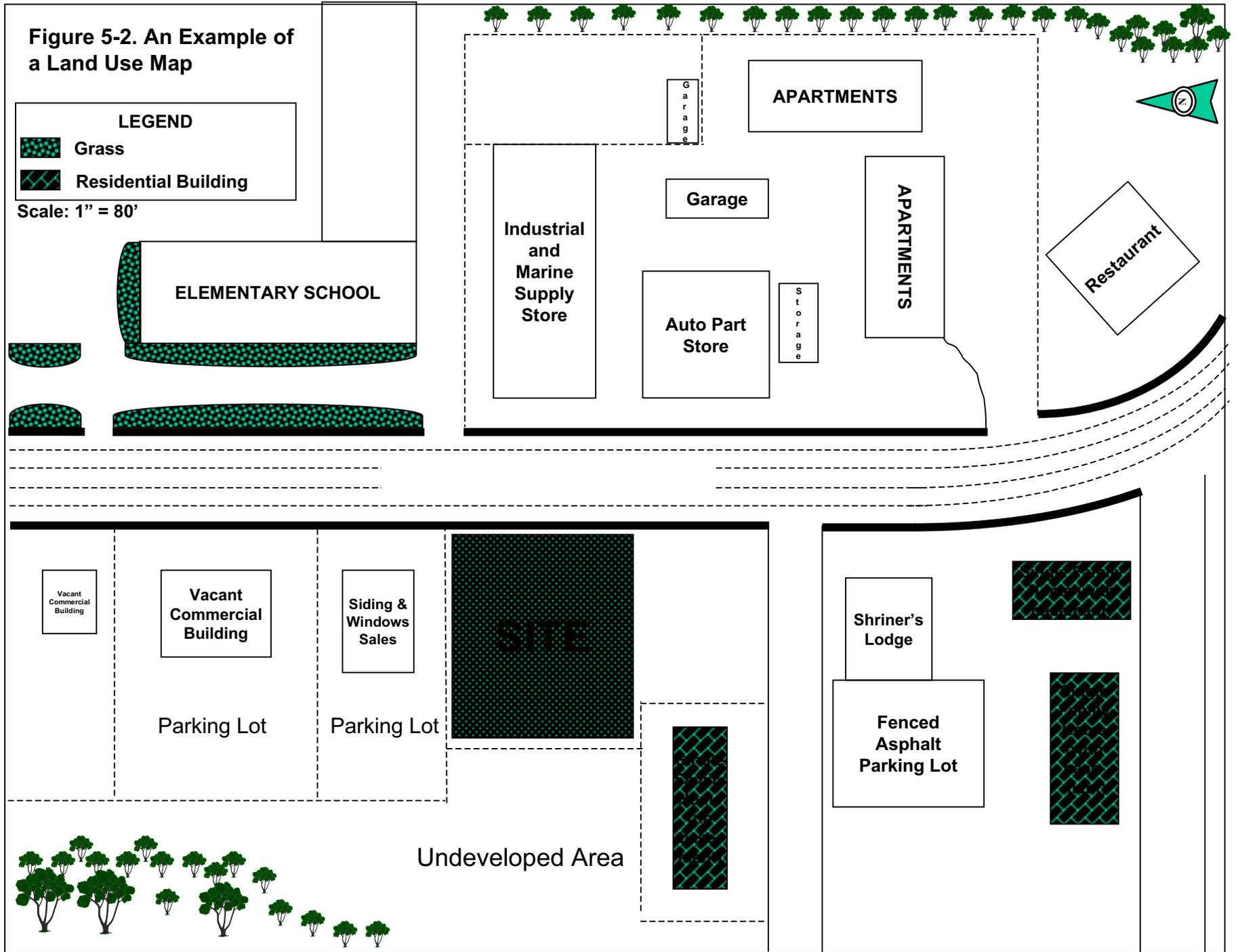


Figure 5-3(a)

ST #	SOIL BORING LOG		BORING NUMBER
R #	OVERSEEING GEOLOGIST	DRILLER	
SITE NAME	DRILLING METHOD	SAMPLING METHOD	
SITE ADDRESS	BOREHOLE DIAMETER	SAMPLING INTERVAL	
DATE OF BORING	TOTAL BORING DEPTH	STATIC WATER LEVEL	

WELL CONSTRUCTION DETAILS	APPROX. DEPTH IN FEET	LITHOLOGIC DESCRIPTION AND REMARKS	PID READING (PPM)	SAMPLE IDENTIFICATION
<div style="border: 1px solid black; width: 50px; height: 400px; margin: auto;"></div>	0			
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
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	23			
	24			
25				

COMMENTS:

NOTES:

- INDICATES SAND SCREEN
- INDICATES MONITORING WELL SCREEN
- INDICATES OBSERVED WATER LEVEL

Figure 5-3(b)

ST #	SOIL BORING LOG	BORING NUMBER MW-1
R #	OVERSEEING GEOLOGIST	DRILLER
SITE NAME	DRILLING METHOD DIRECT PUSH	SAMPLING METHOD SPLIT SPOON
SITE ADDRESS	BOREHOLE DIAMETER 4 INCHES	SAMPLING INTERVAL CONTINUOUS
DATE OF BORING	TOTAL BORING DEPTH 25.0 ft	STATIC WATER LEVEL 17.0 ft

WELL CONSTRUCTION DETAILS	APPROX. DEPTH IN FEET	LITHOLOGIC DESCRIPTION AND REMARKS	PID READING (PPM)	SAMPLE IDENTIFICATION
Cap	0	Asphalt	0	SS-1
Sand	5	Gray clay (CL)	50	SS-2
	10	Silty sand, Slight petroleum odors	350	SS-3
Screened Interval - 0.01 pore size	15	Silty clay, No petroleum odors, moist	100	SS-4
	20	Silty sand, slight petroleum odors, wet	200	SS-5
Bottom of well	25	Silty sand, slight petroleum odors, wet	150	SS-6

COMMENTS:
 Samples sent for laboratory analysis: SS-3, and SS-4.

- NOTES:**
-  INDICATES SAND SCREEN
 -  INDICATES MONITORING WELL SCREEN
 -  INDICATES OBSERVED WATER LEVEL

Figure 5-4(a)

MONITORING WELL INSTALLATION DIAGRAM		BORING/MONITORING WELL NUMBER:	
ST #	OVERSEEING GEOLOGIST	DRILLER	
R #	DRILLING METHOD	SAMPLING METHOD	
SITE NAME	BOREHOLE DIAMETER	SAMPLING INTERVAL	
SITE ADDRESS	TOTAL BORING DEPTH	STATIC WATER LEVEL	
DATE OF CONSTRUCTION	TOP OF CASING ELEVATION	GROUND SURFACE ELEVATION	

WELL CONSTRUCTION DETAILS	LITHOLOGIC DESCRIPTION AND REMARKS	PID READING (PPM)	SAMPLE IDENTIFICATION N
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COMMENTS:			

Figure 5-4(b)

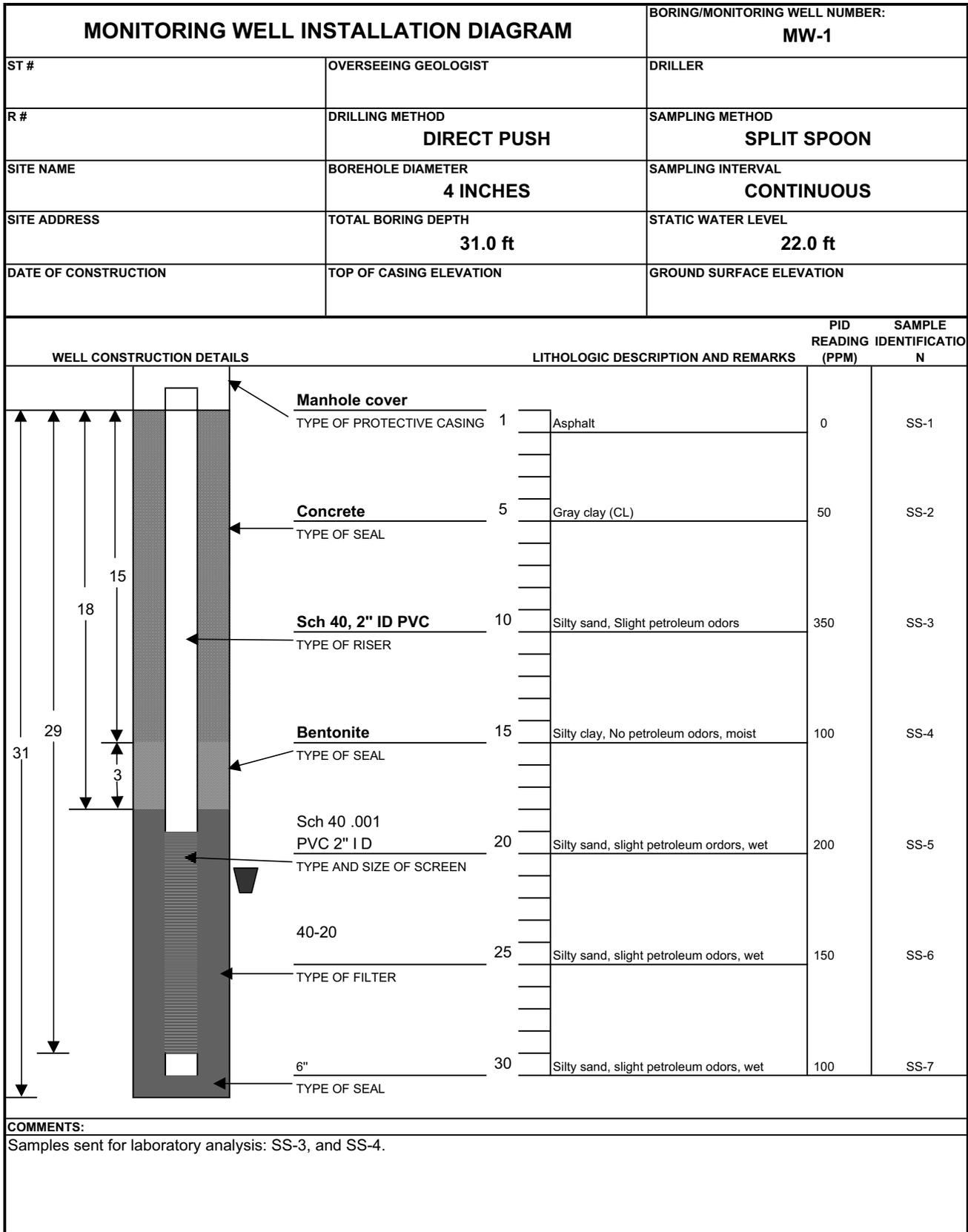


Table 5-1 (Page 1 of 3)
Chemicals of Concern for Different Product Releases

Contaminant	Gasoline	Diesel/ Light Fuel Oils	Product Jet Fuel	Kerosene	Heavy Fuel Oils	Waste/ Used Oil	Analytical Methods		
							Groundwater	Soil	
VOLATILES									
Benzene	a	X	X	X	X	NC	X	8260B	8260B
Toluene	n	X	X	X	X	NC	X	8260B	8260B
Ethylbenzene	n	X	X	X	X	NC	X	8260B	8260B
Xylenes (total)	n	X	X	X	X	NC	X	8260B	8260B
1,2-Dibromoethane / Ethylene dibromide (EDB)	b	X ¹	NC	NC	NC	NC	NC	8260B	8260B
1,2-Dichloroethane / Ethylene dichloride (EDC)	b	X ¹	NC	NC	NC	NC	NC	8260B	8260B
OXYGENATES									
Methyl-tert-butyl-ether (MTBE)	n	X	NC	NC	NC	NC	NC	8260B	8260B
Tertiary amyl methyl ether (TAME)		X	NC	NC	NC	NC	NC	8260B	8260B
Tertiary butyl alcohol (TBA)		X	NC	NC	NC	NC	NC	8260B	8260B
Ethyl-tert-butyl-ether (ETBE)		X	NC	NC	NC	NC	NC	8260B	8260B
Diisopropyl ether (DIPE)		X	NC	NC	NC	NC	NC	8260B	8260B
Ethanol		X	NC	NC	NC	NC	NC	Direct injection GC	NA
Methanol		X	NC	NC	NC	NC	NC	Direct injection GC	NA
TPH									
TPH-GRO		X	NC	NC	NC	NC	X	8260B	8260B
TPH-DRO		NC	X	X	X	X	X	8270C	8270C
TPH-ORO		NC	NC	X	X	X	X	8270C	8270C

Table 5-1 (Page 2 of 3)
Chemicals of Concern for Different Product Releases

Contaminant		Gasoline	Diesel/ Light Fuel Oils	Product Jet Fuel	Kerosene	Heavy Fuel Oils	Waste/ Used Oil	Analytical Methods	
								Groundwater	Soil
PAHs⁴								Groundwater	Soil
Acenaphthene	n	NC	X	X	X	X	X	8270C ³	8270C ³
Anthracene	n	NC	X	X	X	X	X	8270C ³	8270C ³
Benzo(a)anthracene	b	NC	X	X	X	X	X	8270C ³	8270C ³
Benzo(a)pyrene	b	NC	X	X	X	X	X	8270C ³	8270C ³
Benzo(b)fluoranthene	b	NC	X	X	X	X	X	8270C ³	8270C ³
Benzo(k)fluoranthene	b	NC	X	X	X	X	X	8270C ³	8270C ³
Chrysene	b	NC	X	X	X	X	X	8270C ³	8270C ³
Dibenzo(a,h)anthracene	b	NC	X	X	X	X	X	8270C ³	8270C ³
Fluoranthene	n	NC	X	X	X	X	X	8270C ³	8270C ³
Fluorene	n	NC	X	X	X	X	X	8270C ³	8270C ³
Naphthalene	n	X	X	X	X	X	X	8260B ² , 8270C ³	8260B ² , 8270C ³
Pyrene	n	NC	X	X	X	X	X	8270C ³	8270C ³
METALS								Soil and Groundwater	
Arsenic		NC	NC	NC	NC	NC	X	6010B, 6020	
Barium		NC	NC	NC	NC	NC	X	6010B, 6020	
Cadmium		NC	NC	NC	NC	NC	X	6010B, 6020	
Chromium		NC	NC	NC	NC	NC	X	6010B, 6020	
Lead	b	X ¹	NC	NC	NC	NC	X	6010B, 6020	
Selenium		NC	NC	NC	NC	NC	X	6010B, 6020	

Table 5-1 (Page 3 of 3)
Chemicals of Concern for Different Product Releases

- Note:** X Chemical of concern to be analyzed
NC Not a chemical of concern
- 1 Chemical of concern for leaded gasoline
 - 2 When gasoline was the only product released, naphthalene should be analyzed by Method 8260B; if the petroleum released was other than or in addition to gasoline, naphthalene should be analyzed by Method 8270C
 - 3 For 8270 where a detection limit lower than the Estimated Quantitation Limit is required, measures to increase the sensitivity of the method should be taken.
 - a Human carcinogen (Group A under EPA weight of evidence classification system for carcinogenicity)
 - b Probable human carcinogen (Group B1 or B2 under EPA weight of evidence classification system for carcinogenicity)
 - n Non-carcinogen
 - NA Not Applicable – soil samples need not be analyzed for ethanol or methanol
 - 4 Samples must be analyzed for PAHs when TPH-DRO or TPH-ORO are detected in soil at a concentration at or above the RRLs in Table 5-3

Sources:

- U. S. Environmental Protection Agency, November 1986, *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition. Office of Solid Waste and Emergency Response, Washington D.C.
- U.S. Environmental Protection Agency, March 1983, *Methods for Chemical Analysis of Water and Wastes*, Environmental Monitoring and Support Laboratory, Cincinnati, OH 45263.
- Methods Information Communication Exchange, Office of Solid Waste, (703) 821-4690.
- U.S. Environmental Protection Agency, July 1982, *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, EPA-600/4-82-057. Environmental Monitoring and Support Laboratory, Cincinnati, OH 45263.

**Table 5-2
Weight Percents for COCs in Different Products**

	Weight Percent (%)									
	Gasoline		Diesel		Jet Fuel (JP-4 & JP-5)		Kerosene		Fuel Oil No. 6	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
VOLATILES										
Benzene	1.6-2.3	1.90	0.0026-0.1	0.029	0.47-0.5	0.47	---	---	---	---
Toluene	6.4-10	8.10	0.0069-0.7	0.180	1.3-1.6	1.6	---	---	---	---
Ethylbenzene	1.4-2	1.70	0.007-0.2	0.068	0.37-0.69	0.66	---	---	---	---
o-Xylene	2.1-3.1	2.50	0.0012-0.085	0.043	---	0.545	---	---	---	---
m-Xylene	3.9-5.4	4.60	0.009-0.255	0.110	---	0.545	---	---	---	---
p-Xylene	1.6-2.3	1.90	0.009-0.255	0.110	---	0.35	---	---	---	---
Xylenes (total)	---	---	---	0.5	---	---	---	---	---	---
1,2-Dibromoethane/Ethylene dibromide (EDB)	---	---	---	---	---	---	---	---	---	---
1,2-Dichloroethane/Ethylene dichloride (EDC)	---	---	---	---	---	---	---	---	---	---
PAHs										
Acenaphthene	---	---	---	---	---	---	---	0.0047	---	---
Anthracene	---	---	3.0E6 -0.02	5.80E-03	---	---	---	0.00012	---	0.005
Benzo(a)anthracene	---	---	2.0E-6 - 6.7E-4	9.60E-05	---	---	---	---	0.0029-0.15	0.055
Benzo(a)pyrene	---	---	5.0E-6 - 8.4E-4	2.20E-04	---	---	---	---	---	0.0044
Benzo(b)fluoranthene	---	---	1.55E-07 - 9.5E-05	1.55E-04	---	---	---	---	---	0.022
Benzo(k)fluoranthene	---	---	1.55E-07 - 9.5E-06	1.55E-04	---	---	---	---	---	0.022
Chrysene	---	---	---	4.50E-05	---	---	---	---	0.0029-0.31	0.069
Dibenz(a,h)anthracene	---	---	---	---	---	---	---	---	---	---
Fluoranthene	---	---	6.8E-7 - 0.02	0.0059	---	---	---	0.00086	---	0.024
Fluorene	---	---	0.034-0.15	0.086	---	---	---	---	---	---
Naphthalene	0.15-0.36	0.25	0.01-0.8	0.26	0.25-0.5	0.41	0.15-0.46	0.31	0.00021-0.015	0.0042
Pyrene	---	---	0.000018-0.015	0.0046	---	---	---	0.00024	---	0.0023

Notes:

Data from Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), May 1998. TPHCWG Series Volume 2: Composition of Petroleum Mixtures.

1. ---: Not available. For these COCs pure product solubilities and saturated vapor concentrations were used.

See discussion at 6.8.3 and Section B.8

2. Jet Fuel: Average values of JP-4 and JP-5 are taken.

3. Diesel: Values were available for m+p-Xylene. Each was considered 50% composition.

4. Diesel and Fuel Oil No. 6: Values were available for Benzo(b+k)fluoranthene. Each was considered 50% composition.

**Table 5-3
Required Reporting Limits**

Listed below are the required reporting limits (RRLs) for the methods specified in the MRBCA guidance document. All listed RRL's should be viewed as conservative numbers and do not represent the absolute lowest quantitation levels achievable. Most laboratories should be able to obtain RRL's at or below the listed values.

VOLATILES

<u>Compound</u>	<u>Method</u>	<u>Water PQL</u>	<u>Soil PQL</u>
Benzene	8260B	5 µg/L	25 µg/Kg
Toluene	8260B	5 µg/L	25 µg/Kg
Ethylbenzene	8260B	5 µg/L	25 µg/Kg
Total Xylenes	8260B	10 µg/L	50 µg/Kg
Ethylene Dichloride (EDC)	8260B	5 µg/L	25 µg/Kg
Ethylene Dibromide (EDB)	8260B	5 µg/L	25 µg/Kg

OXYGENATES

<u>Compound</u>	<u>Method</u>	<u>Water PQL</u>	<u>Soil PQL</u>
MTBE	8260B	5 µg/L	25 µg/Kg
TAME	8260B	50 µg /L	250 µg/Kg
TBA	8260B	50 µg/L	250 µg/Kg
ETBE	8260B	5 µg/L	25 µg/Kg
DIPE	8260B	50 µg/L	250 µg/Kg
Ethanol (1)	8015	1 mg/L	(2)
Methanol (1)	8015	1 mg/L	(2)

TPH

<u>Compound</u>	<u>Method</u>	<u>Water PQL</u>	<u>Soil PQL</u>
TPH-GRO	8260B	1 mg/L	20 mg/Kg
TPH-DRO	8270C	1 mg/L	20 mg/Kg
TPH-ORO	8270C	1 mg/L	20 mg/Kg

PAH'S

<u>Compound</u>	<u>Method</u>	<u>Water PQL</u>	<u>Soil PQL</u>
Acenaphthene	8270C	10 µg/L	660 µg/Kg
Anthracene	8270C	10 µg/L	660 µg/Kg
Benzo(a)anthracene	8270C	10 µg/L	660 µg/Kg
Benzo(a)pyrene	8270C	10 µg/L	660 µg/Kg
Benzo(b)fluoranthene	8270C	10 µg/L	660 µg/Kg
Benzo(k)fluoranthene	8270C	10 µg/L	660 µg/Kg
Chrysene	8270C	10 µg/L	660 µg/Kg
Dibenzo(a,h)anthracene	8270C	10 µg/L	660 µg/Kg
Fluoranthene	8270C	10 µg/L	660 µg/Kg
Fluorene	8270C	10 µg/L	660 µg/Kg
Naphthalene	8270C	10 µg/L	660 µg/Kg
Pyrene	8270C	10 µg/L	660 µg/Kg

METALS

<u>Metals</u>	<u>Method</u>	<u>Water PQL</u>	<u>Soil PQL</u>
Arsenic	6010B	50 µg/L	2500 µg/Kg
Barium	6010B	5 µg/L	500 µg/Kg
Cadmium	6010B	5 µg/L	500 µg/Kg
Chromium	6010B	5 µg/L	500 µg/Kg
Lead	6020	5 µg/L	500 µg/Kg
Selenium	6010B	50 µg/L	2500 µg/Kg

(1) These compounds are to be analyzed by direct injection and not purge and trap.

(2) Soil samples will not be analyzed for Ethanol or Methanol.

LABORATORY ANALYSIS FACT SHEET

TPH-GRO by Method 8260B

The Missouri DNR has adopted SW-846 method 8260B as the method of choice for the detection and quantitation of TPH-GRO. The following items represent exceptions or clarifications to the method as written.

Sample Introduction

1. Samples are purged onto the GC/MS system using all protocols specified in SW-846 method 5035 or 5035A.
2. Surrogates and internal standards specified by method 8260B are added to water and soil samples prior to purging. Since the surrogate Dibromofluoromethane is not related to compounds detected by this method, it does not have to be reported nor does it have to meet any acceptance criteria.

Sample Analysis

1. The GC/MS system is tuned to BFB tune criteria listed in method 8260B, at the frequency specified in method 8260B. Alternative tuning criteria as specified in section 7.3 of method 8260B is also acceptable, as long as method performance is not adversely affected.
2. The GC/MS operating conditions specified as guidance in Section 7.3 of Method 8260B are acceptable.
3. A 5 point standard curve is used to quantitate TPH-GRO. Quantitation is by external standard.
4. The stock standard solution used to prepare calibration standards is a mixture of unleaded gasoline and Number 2 diesel fuel. The stock solution and all calibration standards use Methanol as the solvent. Each component should be at a concentration of 1000 mg/L in the stock standard.
5. The lowest calibration standard should be at the reporting limit for the method. The highest calibration standard must not exceed the linear range of the system.
6. Retention time windows are defined for TPH-GRO by analyzing a standard containing C6 and C10. The retention time window for TPH-GRO is defined as beginning 0.1 minutes before C6 to 0.1 minutes after C10. The standard containing C6 and C10 must be analyzed every day samples are analyzed in order to verify that the retention time windows are constant.
7. Because the retention time window will be several minutes wide for TPH-GRO, the GC/MS data system may not accurately or appropriately establish the proper baseline

for calibration or quantitation. The analyst **must** visually examine the computer-generated baseline for every analytical run, and manually adjust the baseline when needed. A properly drawn baseline must extend over the entire retention time window and include the area under the entire TPH-GRO series of peaks. It is **not appropriate** to draw the baseline “peak to peak.”

8. Individual quantitation ions are not appropriate for TPH-GRO calibration and quantitation. The Total Ion Chromatogram (TIC) must be used to calculate the area under the peak for TPH-GRO calibration and quantitation determinations over the entire retention time window.
9. Area counts for the internal standards and surrogates added during sample preparation must be subtracted from the total area count for TPH-GRO. This is accomplished by subtracting the area count of the method blank from all subsequent calibration and analytical runs.
10. The %RSD for the calibration curve for TPH-GRO must be less than or equal to 20 percent, so that linearity through the origin can be assumed and an average calibration factor used for calculations.
11. A continuing calibration check verification standard (CCV) must be analyzed every 12 hours of sample analysis. The CCV must contain all analytes reported by this method. The standard concentration should be at the mid-point of the calibration curve. If the percent difference (%D) for the CCV is less than or equal to 20%, the initial calibration is assumed to be valid. If the %D is greater than 20%, corrective action must be taken prior to sample analysis.
12. A method blank must be analyzed for every 20 samples analyzed. Additionally minimum quality control samples per every 20 samples include a Laboratory Control Sample (LCS) and Matrix Spike/Matrix Spike Duplicate (MS/MSD). Ideally, the spiking solution(s) for the LCS and MS/MSD would contain TPH-GRO, BETX, chlorinated compounds, and oxygenates. It may not be possible however to have every component in the spiking solution(s) for the LCS and MS/MSD samples. It is acceptable to spike the LCS and MS/MSD with different components, as long as TPH-GRO, BETX, chlorinated compounds, and oxygenates are present in either the LCS or the MS/MSD samples.
13. All of the BTEX, chlorinated compounds and oxygenates analyzed by 8260B are by internal standard, using all criteria specified in 8260B. This includes the RSD requirement of 15% for the compounds. If 15% RSD is not achieved, additional calibration options specified in Method 8000B may be employed.

Should questions arise concerning TPH analysis by Method 8270C, feel free to contact either of the following people:

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LABORATORY ANALYSIS FACT SHEET TPH-DRO and TPH-ORO by Method 8270C

The Missouri DNR has adopted SW-846 method 8270C as the method of choice for the detection and quantitation of TPH-DRO and TPH-ORO. The following items represent exceptions or clarifications to the method as written.

Sample Preparation

1. Samples are extracted by the appropriate matrix defined SW-846 extraction methods specified by Method 8270C.
2. Surrogates specified by method 8270C are added to water and soil samples prior to extraction. Only the Base Neutral surrogates need to be added.
3. Internal standards specified by method 8270C are added to sample extracts immediately prior to extract analysis. Only the internal standards specified by 8270C for the PAH compounds are required for analysis and must meet the acceptance criteria.

Sample Analysis

1. The GC/MS system is tuned to DFTPP tune criteria listed in method 8270C, at the frequency specified in method 8270C. Alternative tuning criteria as specified in section 7.3.1.2 of method 8270C is also acceptable, as long as method performance is not adversely affected.
2. The DFTPP tuning standard **is not required** to contain 4,4'-DDT, pentachlorophenol, and benzidine to monitor injection port inertness and GC column performance.
3. The GC/MS operating conditions specified as guidance in Section 7.3 of Method 8270C are acceptable with the exception of mass range. Mass range should be changed from 35-500 amu to 35-550 amu. This is required in order to quantitate and detect C35.
4. A 5 point standard curve is used to quantitate TPH-DRO and TPH-ORO. Quantitation is by external standard.
5. The stock standard solution used to prepare calibration standards is a mixture of unleaded gasoline and Number 2 diesel fuel. The stock standard and all calibration standards use Methylene Chloride as the solvent. Each component should be at a concentration of 1000 mg/L in the stock standard.
6. The lowest calibration standard should be at the reporting limit for the method. The highest calibration standard must not exceed the linear range of the system.

7. Retention time windows are defined for TPH-DRO and TPH-ORO by analyzing a standard containing C10, C21, and C35. The retention time window for TPH-DRO is defined as beginning 0.1 minutes after C10 to 0.1 minutes after C21. The window for TPH-ORO is defined as beginning 0.1 minutes after C21 to 0.1 minutes after C35. The standard containing C10, C21, and C35 must be analyzed every day samples are analyzed in order to verify that the retention time windows are constant.
8. Because the retention time window will be several minutes wide for both TPH-DRO and TPH-ORO, the GC/MS data system may not accurately or appropriately establish the proper baseline for calibration or quantitation. The analyst **must** visually examine the computer-generated baseline for every analytical run, and manually adjust the baseline when needed. A properly drawn baseline must extend over the entire retention time window and include the area under the entire TPH-DRO or TPH-ORO series of peaks. It is **not appropriate** to draw the baseline “peak to peak.”
9. Individual quantitation ions are not appropriate for TPH-DRO and TPH-ORO calibration and quantitation. The Total Ion Chromatogram (TIC) must be used to calculate the area under the peak for TPH-DRO and TPH-ORO calibration and quantitation determinations over the entire retention time window.
10. It is highly likely that the calibration standards used for this method will have little presence in the C21 to C35 window. The response factor calculated for the C10 to C21 window must be used for the C21 to C35 window.
11. Area counts for the internal standards and surrogates added during sample preparation must be subtracted from the total area count for TPH-DRO and TPH-ORO. This is accomplished by subtracting the area count of the method blank from all subsequent calibration and analytical runs.
12. The %RSD for the calibration curve for TPH-DRO and TPH-ORO must be less than or equal to 20 percent, so that linearity through the origin can be assumed and an average calibration factor used for calculations.
13. A continuing calibration verification standard (CCV) must be analyzed every 12 hours of sample analysis. The CCV must contain all analytes reported by this method. The standard concentration should be at the mid-point of the calibration curve. If the percent difference (%D) for all CCV compounds is less than or equal to 20%, then the initial calibration is assumed to be valid. If the %D is greater than 20%, corrective action must be taken prior to sample analysis.
14. A method blank must be analyzed for every extraction group, with each extraction group not to exceed 20 samples. Additionally minimum quality control samples per extraction group include a Laboratory Control Sample (LCS) and Matrix Spike/Matrix Spike Duplicate (MS/MSD). Ideally, the spiking solution(s) for the LCS and MS/MSD would contain TPH-DRO, TPH-ORO, and the PAH's quantitated by this method. It may not be possible however to have every component in the

spiking solution(s) for the LCS and MS/MSD samples. It is acceptable to spike the LCS and MS/MSD with different components, as long as TPH-DRO, TPH-ORO, and the PAH's are present in either the LCS or the MS/MSD samples.

15. If a sample has a sufficient TPH-DRO or TPH-ORO concentration to require PAH analysis, the same analytical run can be processed against a standard 8270C method containing the PAH's of interest.
16. All calibration and quantitation data for PAH analysis is by internal standard, using all criteria specified in 8270C. This includes the RSD requirement of 15% for the PAH compounds. If 15% RSD is not achieved, additional calibration options specified in Method 8000B may be employed.

Should questions arise concerning TPH analysis by Method 8270C, feel free to contact either of the following people:

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MRBCA LABORATORY REQUIREMENTS

I. REQUIREMENTS FOR ALL ANALYSES

- A. Percent moisture determinations must be performed on all soil samples using either the ASTM oven drying method or the Karl Fisher method.
- B. Method 5035 must be used for soil sample collection and analysis when Volatile Organic Compounds are to be analyzed.
- C. Appropriate standards must be analyzed by the instrumental conditions of Method 8260B to allow the laboratory to complete the Gasoline Range Organics (GRO) quantitations and Method 8270C to complete the Diesel Range Organics (DRO) and Oil Range Organics (ORO) quantitations.
- D. Specific quantitation ranges for the GRO, DRO, and ORO determinations are defined in Table F-1 of the guidance document *Missouri Risk-Based Corrective Action Process for Petroleum Storage Tanks*, October 2003. The quantitation ranges are C6 through C10 for GRO, C10 through C21 for DRO, and C21 through C35 for ORO.

II. ADDITIONAL REQUIREMENTS FOR SOURCE DETERMINATION

- A. At the direction of MDNR, in addition to the retention time fraction determination, **additional whole fraction standards** must be analyzed with either GC/MS or GC analyses to allow for both qualitative and quantitative identification of the specific type of petroleum product present. Additional standards include: gasoline, #1-#5 diesel, mineral spirits, kerosene, JP4, jet fuel, motor oil, and hydraulic fluid.
- B. Quantitation must be accomplished by summing areas of all compounds from the retention time window of each standard that include the fraction pattern of each petroleum product.
- C. Results must be reported as ### µg/L as gasoline, ### µg/L as diesel, etc.

III. REPORTING REQUIREMENTS

- A. All soil results must be reported as dry weights and clearly identified as such.
- B. The method of moisture determination must be clearly identified and reported along with the actual percent moisture result.
- C. Source determination results must be reported as indicated in II.C. above.
- D. All other results must be reported as specified in the appropriate analytical method.

ATTACHMENT A

Ecological Risk Assessment Tier 1 Screening Checklist for Potential Receptors and Habitat Checklist #1

1. Is the site less than (<) ½ mile to a surface water resource (pond, river, lake, etc.)?
2. Are wetlands (e.g., marshes, swamps, fens) on or adjacent to the site?
3. Are contaminated soils uncovered or otherwise accessible to ecological receptors and the elements?
4. Are there karstic features (see Ecological Risk Assessment Figure #2 for definition) on or within a ½ mile radius of the site?

Note: A professional opinion may be necessary to make this determination. The Missouri Environmental Geology Atlas (MEGA), published recently by the Department of Natural Resources, Geological Survey and Resource Assessment Division (GSRAD), provides several state-wide, karst-related data sets, as well as others related to geology and hydrology, in a geographic information system format, that can assist in this determination. MEGA, including software to view the data sets, may be obtained from GSRAD by calling (573) 368-2125.

5. Are there federal or state rare, threatened, or endangered species on or within a ½ mile radius of the site? Note: The ½ mile radius limit does not necessarily apply to situations where a hydrogeological connection exists between the site and karstic features.
6. Are there one or more environmentally sensitive areas (see Ecological Risk Assessment Figure #1 for definition) at or within a ½ mile radius of the site?
7. Are commercially or recreationally important species (fauna or flora) on or within a ½ mile radius of the site?

If the answer is “Yes” to any of the above questions, then complete Ecological Risk Assessment Tier 1 Checklist for Potential Exposure Pathways, Checklist #2.

ATTACHMENT B

Ecological Risk Assessment Tier 1 Screening Checklist for Potential Receptors and Habitat Checklist #2

1.a.) Can contaminants associated with the site leach, dissolve, or otherwise migrate to groundwater?

1.b.) Are contaminants associated with the site mobile in groundwater?

1.c.) Does groundwater from the site discharge to ecological receptor habitat?

Question 1: Could contaminants associated with the site reach ecological receptors via groundwater?

2.a.) Is Non-Aqueous Phase Liquid (NAPL) present at the site?

2.b.) Is NAPL migrating?

2.c.) Could NAPL discharge occur where ecological receptors are found?

Question 2: Could contaminants from the site reach ecological receptors via migration of NAPL?

3.a.) Are contaminants present in surface soils?

3.b.) Can contaminants be leached from or be transported by erosion of surface soils?

Question 3: Could contaminants reach ecological receptors via erosional transport of contaminated soils or via precipitation runoff?

4.a.) Are contaminants present in surface soil or on the surface of the ground?

4.b.) Are potential ecological receptors on the site?

Question 4: Could contaminants reach ecological receptors via direct contact?

5.a.) Are contaminants present on the site volatile?

5.b.) Could contaminants on the site be transported in air as dust or particulate matter?

Question 5: Could contaminants reach ecological receptors via inhalation of volatilized contaminants or contaminants adhered to dust in ambient air or in subsurface burrows?

6.a.) Are contaminants present in surface and shallow subsurface soils or on the surface of the ground?

6.b.) Are contaminants found in soil on the site taken up by plants growing on the site?

6.c.) Do potential ecological receptors on or near the site feed on plants (e.g., grasses, shrubs, forbs, trees, etc.) found on the site?

6.d.) Do contaminants found on the site bioaccumulate?

Question 6: Could contaminants reach ecological receptors via ingestion of either soil, plants, animals, or contaminants directly?

7.a.) Are there karstic features (see Ecological Risk Assessment Figure #2 for definition) on or within a ½ mile radius of the site?

7.b.) Is there a hydrogeological connection between the site and karstic features such as seeps, springs, streams or other surface water bodies?

Question 7: Could contaminants reach ecological receptors via transport through a Karst system?

Note: A professional opinion may be necessary to answer 7.a, 7.b, and Question 7. The Missouri Environmental Geology Atlas (MEGA), published recently by the MDNR, Geological Survey and Resource Assessment Division (GSRAD), provides several state-wide, karst-related data sets, as well as others related to geology and hydrology, in a geographic information system format, that can assist in answering these questions. The MEGA, and software to view it, can be obtained from GSRAD by calling (573) 368-2125.

If the answer to one or more of the seven above questions is yes, MDNR may require further assessment to determine whether the site poses an unacceptable risk to ecological receptors.

Ecological Risk Assessment
Figure #1: Environmentally Sensitive Areas

Environmentally Sensitive Areas are areas of special significance due to the flora or fauna found on the area, the sensitive nature of natural features found on the area, historical considerations, or for other reasons associated with the environment of the area.

Examples of environmentally sensitive areas include, but are not necessarily limited to, the following:

- National and state parks,
- Designated and proposed federal and state wilderness and natural areas,
- Endangered, rare, and threatened species habitat as designated by the U.S. Department of the Interior or the Missouri Department of Conservation,
- National monuments,
- National and state historic sites,
- National and state lakeshore and river recreational areas,
- Federal or state designated scenic or wild rivers,
- Habitat of federal or state designated or proposed endangered, rare, or threatened species, and species under review as to their endangered, rare, or threatened status,
- National and state preserves and forests,
- National and state wildlife refuges,
- Critical fish and shellfish spawning areas,
- Critical migratory pathways and feeding areas for anadromous fish species within river reaches or areas in lakes where such species spend extended periods of time,
- Terrestrial areas used for breeding by large or dense aggregations of faunal species,
- State lands designated by the Missouri Department of Conservation for wildlife or game management,
- Wetlands, and
- Outstanding state resource waters as designated by the Missouri Clean Water Commission.

Ecological Risk Assessment
Figure #2: Karst Features

Karst: A distinctive set of geomorphic landforms resulting from the development of extensive subsurface solution channels and caves in carbonate rocks (Boulding, 1995).